

# Purchaser Licensing, Point-of-Sale Background Check Laws, and Firearm Homicide and Suicide in 4 US States, 1985–2017

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**Objectives.** To estimate and compare the effects of state background check policies on firearm-related mortality in 4 US states.

**Methods.** Annual data from 1985 to 2017 were used to examine Maryland and Pennsylvania, which implemented point-of-sale comprehensive background check (CBC) laws for handgun purchasers; Connecticut, which adopted a handgun purchaser licensing law; and Missouri, which repealed a similar law. Using synthetic control methods, we estimated the effects of these laws on homicide and suicide rates stratified by firearm involvement.

**Results.** There was no consistent relationship between CBC laws and mortality rates. There were estimated decreases in firearm homicide (27.8%) and firearm suicide (23.2%–40.5%) rates associated with Connecticut's law. There were estimated increases in firearm homicide (47.3%), nonfirearm homicide (18.1%), and firearm suicide (23.5%) rates associated with Missouri's repeal.

**Conclusions.** Purchaser licensing laws coupled with CBC requirements were consistently associated with lower firearm homicide and suicide rates, but CBC laws alone were not.

**Public Health Implications.** Our results contribute to a body of research showing that CBC laws are not associated with reductions in firearm-related deaths unless they are coupled with handgun purchaser licensing laws. (*Am J Public Health*. 2020;110:1546–1552. doi:10.2105/AJPH.2020.305822)

Federal Bureau of Investigation or state law enforcement agencies to determine whether the applicant is legally qualified to acquire a firearm. Under purchaser licensing laws, a prospective purchaser is required to apply for a license directly to a state or local law enforcement agency that vets the application and initiates a background check, often aided by mandated fingerprinting. Private sellers and federally licensed dealers can sell handguns only to individuals with valid licenses. Absent a CBC law, residents of states with a licensing law may not need to undergo a point-of-sale background check if they have a valid license to purchase. In some states, a valid permit to carry a concealed handgun can substitute for a license to purchase or a point-of-sale background check.

Although individual-level studies of background checks suggest that they are effective,<sup>2–4</sup> recent state-level research casts doubt on the population-level effectiveness of CBC laws alone in reducing firearm-related deaths.<sup>5–7</sup> Studies suggesting CBC law effectiveness have methodological limitations including cross-sectional designs<sup>8</sup> and exclusion of CBC laws that apply only to handguns.<sup>9</sup> In 2018, handguns accounted for 90% of the firearms used in homicides in which the type of firearm was specified.<sup>10</sup>

Studies in several US states have shown that firearm purchaser licensing laws are

Firearms were the second-leading mechanism of death by injury in the United States in 2018, resulting in 39 740 deaths.<sup>1</sup> Laws intended to keep firearms from individuals at the highest risk of harming themselves or others may reduce firearm-related deaths, but they rely on background checks and other systems for vetting those seeking to acquire firearms.

Although federal law requires individuals who purchase firearms from federally licensed dealers to pass a background check, no background check is required for purchases from private sellers. As of January 2020, 21 states required a background check for at least some private firearm sales. These state laws can be sorted into 2 broad categories: point-of-sale comprehensive background check

(CBC) laws and purchaser licensing laws. Both categories require firearm purchasers to pass a background check prior to a sale or transfer, but they differ with respect to timing and process.

CBC laws require a background check for private purchasers at the point of sale. Prospective purchasers and sellers typically go to federally licensed dealers who process the transfer by submitting applications to the

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ATTACHMENT 9, Page 1 of 7

to Marshall Declaration

USDC Case No. 2:22-cv-01815-IM

AJPH October 2020, Vol 110, No. 10

associated with reductions in firearm homicides.<sup>3,8</sup> Connecticut enacted a handgun purchaser licensing law in 1995 that was associated with significant decreases in rates of firearm homicides<sup>11</sup> and firearm suicides.<sup>12</sup> After the 2007 repeal of Missouri's handgun purchaser licensing law that also functioned as a point-of-sale CBC law, rates of firearm homicides<sup>13,14</sup> and suicides<sup>12</sup> increased in the state, as did indicators of guns diverted for criminal use.<sup>15</sup> Critics of these studies identified the relatively short periods of postlaw data in Missouri and Connecticut and possible overreliance on Rhode Island as a point of comparison with Connecticut's trends.<sup>16</sup>

In this study, we improved on prior analyses of purchaser licensing laws in Connecticut and Missouri and applied similar methods to analyze point-of-sale-only laws in Maryland and Pennsylvania, which adopted typical CBC laws in 1996 and 1995, respectively. We lengthened the period of observation for Connecticut and Missouri and applied a uniform analytic approach across all 4 states, comparing the findings with respect to CBC and licensing policies.

## METHODS

Following the example of some earlier studies of licensing and CBC laws,<sup>6,7,11,13</sup> we used the synthetic control method<sup>17</sup> to compare each state's homicide and suicide rates with estimates of the counterfactual: each intervention state's forecasted homicide and suicide rates had the law not been enacted. In accord with the synthetic control method, we used a series of preintervention outcomes and other covariates to construct a convex combination of weighted donor states that best approximated the pre-treatment outcome and covariate trends in the treated state (the state with the relevant policy change). The weights were determined on the basis of their capability to minimize the prediction error during the period prior to the law change being evaluated. The donor pool of potential controls contained states that did not have the law of interest in place during the study period. This weighted combination of donor states—the synthetic control—was compared with the treated state in the posttreatment period to estimate the effect of the intervention. We present the mean square predicted error

(MSPE) for the preintervention period as a measure of model fit.

Each state law change was evaluated for its association with rates of firearm homicides, nonfirearm homicides, firearm suicides, and nonfirearm suicides. Each prelaw period was 10 years; the postlaw period was determined by the amount of postlaw data available after the law change and the legal environment of each state. The time period for Pennsylvania's 1995 CBC law ran from 1985 to 2017. For Maryland's 1996 CBC law, the postlaw period was truncated at 2013 because the state adopted a handgun purchaser licensing law late that year. The study period for Missouri's repeal of its 2007 licensing law started in 1997 and ended in 2016 because Missouri began allowing permitless concealed carry on January 1, 2017. Prior work has shown an association between less restrictive concealed carry laws and violent crime.<sup>18</sup> For Connecticut, we present data through 2017 but also provide estimates that exclude 2013 to 2017 because of a state program under which several cities began implementing focused deterrence programs to curb gang violence.<sup>19</sup>

The donor pools of potential controls for Pennsylvania (29 states), Maryland (33 states), and Connecticut (39 states) consisted of states that did not have the law of interest in place throughout the study periods just described. Missouri's donor pool (8 states) consisted of states that had a purchaser licensing law for the entirety of the study period.

For each model, the effect was estimated by determining the difference in postlaw means between the treated state and the synthetic control and calculating the percentage increase or decrease from the synthetic control. To assess whether the estimated effects of CBC and purchaser licensing laws were unusual with respect to effects that would be estimated in other states, we performed placebo tests with all states in the donor pool for each law change.<sup>17</sup> The estimated effect for the treated state was compared with the placebo effect distribution estimated from the donor states. To make a reliable inference, we had to find that only a small proportion of control states had a more extreme placebo effect estimate than the effect estimated for the true treated state. We used this proportion as a permutation distribution pseudo *P* value. Because a synthetic control that adequately fit the pre-intervention data could not be estimated for

each donor state, we restricted the placebo tests to the subset of donor states with prelaw MSPEs less than 5 times the treated state's prelaw MSPE to avoid comparisons with synthetic controls that had poor fits.

We used death certificate data obtained from the National Center for Health Statistics through the CDC WONDER database to generate homicide and suicide mortality rates.<sup>20</sup> Because annual state suicide data are often volatile, we smoothed suicide mortality rates by analyzing 3-year moving averages. Annual state-level predictors were chosen on the basis of prior research and theoretical relationships between sociodemographic variables and the dependent variables of interest.

For homicide, state-level predictors were population size, law enforcement expenditures per capita, law enforcement officer population, percentage of the population identifying as Black, percentage of the population identifying as Latino, the Gini coefficient (a measure of income inequality), percentage of the population 15 to 24 years of age, percentage of the population 0 to 18 years of age, percentage of the population living in a metropolitan statistical area, robbery rate, population density, poverty rate, jobs per capita, average individual income per capita, unemployment rate, and incarceration rate.

For suicide, the predictors were unemployment rate, poverty rate, percentage of the population identifying as male, percentage of the population reporting being married, percentage of the population identifying as Black, percentage of the population identifying as a veteran, percentage of the population living in a metropolitan statistical area, ethanol consumption per capita, religious adherence, educational attainment, and overdose rate.

Each model included prelaw averages for all of these predictors and values of the outcome variable for every other prelaw year. When necessary, missing predictor data from intercensal years were interpolated. These data were obtained from the Bureau of Economic Analysis,<sup>21</sup> the Bureau of Labor Statistics,<sup>22</sup> the Census Bureau,<sup>23</sup> and the Federal Bureau of Investigation's Uniform Crime Report.<sup>24</sup>

## RESULTS

The synthetic control models revealed no consistent relationship between

ATTACHMENT, Page 2 of 7

to Marshall Declaration

USDC Case No. 2:22-cv-01815-IM

McCourt et al. Peer Reviewed Research 1547

comprehensive background check laws and firearm mortality in Maryland and Pennsylvania. There were, however, consistent relationships between firearm mortality and purchaser licensing laws in Connecticut and Missouri. Measures of synthetic control model fit, donor states contributing to each synthetic control, and donor weights are presented in Appendix Table A (available as a supplement to the online version of this article at <http://www.ajph.org>). The placebo results we report are the proportions of control states that had a more extreme placebo effect estimate than the effect estimated for the true treated state. We also report these proportions as fractions, with the number of states with a more extreme placebo effect estimate in the numerator and the number of total control states in the denominator. We restricted the denominator to the subset of donor states with prelaw MSPEs less than 5 times the treated state's prelaw MSPE.

## Comprehensive Background Check Laws

Results for Maryland and Pennsylvania are presented in Table 1. After implementation of a CBC law (1996–2013), Maryland saw a 17.5% increase in firearm homicide rates relative to its synthetic control (placebo = 0.06; 2/32) and a 33.2% increase in nonfirearm homicide rates (placebo = 0.06; 2/33). Maryland's firearm suicide rate was 15.4% lower than that of its synthetic control following the state's passage of a CBC law

(placebo = 0.13; 3/24), but there was also a 21.8% decrease in nonfirearm suicides (placebo = 0.03; 1/32) relative to the synthetic control.

Pennsylvania's firearm homicide rate was 21.5% higher than that of its synthetic control for the post-CBC law period 1996 to 2017 (placebo = 0.13; 3/23), whereas its nonfirearm homicide rate was 10.0% lower (placebo = 0.26; 5/19). During the same period, Pennsylvania saw a 5.3% increase in firearm suicides relative to its synthetic control (placebo = 0.21; 4/19) and an 11.8% decrease in nonfirearm suicides (placebo = 0.09; 1/11).

We performed post hoc analyses to determine whether these results might be partially explained by factors unique to the largest cities in Maryland and Pennsylvania, which accounted for a substantial share of homicides in the 2 states. When Baltimore data were excluded from the Maryland model, the CBC law was associated with insignificant increases in both firearm (3.1%; placebo = 0.34; 11/32) and nonfirearm (10.8%; placebo = 0.17; 4/24) homicides. However, the estimated effect of the CBC law in Pennsylvania on firearm homicides did not diminish when Philadelphia data were excluded (23.9%; placebo = 0.14; 2/14). Nonfirearm homicides increased 4.1% in the model without Philadelphia (placebo = 0.33; 5/15).

## Purchaser Licensing Laws

Purchaser licensing laws were more clearly associated with changes in firearm homicide

rates (Table 2 and Figure 1). After implementation of Connecticut's licensing law, there was a 27.8% decrease in firearm homicides relative to the state's synthetic control from 1995 to 2017 (placebo = 0.03; 1/38). This effect was similar when deaths from the 2012 Newtown school shooting were removed from homicide counts (Appendix Table J, available as a supplement to the online version of this article at <http://www.ajph.org>; change = -24.2%; placebo = 0.00; 0/35). The estimate for the effect of Connecticut's licensing law is somewhat smaller if the data extend only to 2012, before focused deterrence programs curbed urban gang violence in several of the state's cities (Appendix Table I, available as a supplement to the online version of this article at <http://www.ajph.org>; change = -19.9%; placebo = 0.03; 1/34). Nonfirearm homicide rates did not change relative to the synthetic control over the period from 1995 to 2017 (placebo = 0.61; 20/33).

From the 1995 implementation of its law through 2017, Connecticut saw a 32.8% decrease in firearm suicides (Table 2 and Figure 2; placebo = 0.06; 2/35) and a 3.3% decrease in nonfirearm suicides (placebo = 0.60; 15/25) relative to its synthetic control. In 1999, Connecticut adopted a law akin to an extreme risk protection order law. Under this law, police are authorized to temporarily take guns from individuals when there is probable cause to believe that they are at imminent risk of injuring themselves or

**TABLE 1—Overall Synthetic Control Results for Point-of-Sale Comprehensive Background Check (CBC) Laws: Maryland and Pennsylvania, 1995 and 1996**

Model	Firearm			Nonfirearm		
	MSPE	Effect, %	Placebo No./Total No. (%) <sup>a</sup>	MSPE	Effect, %	Placebo No./Total No. (%) <sup>a</sup>
<b>Homicide</b>						
Maryland 1996 CBC law	0.531	+17.5	2/32 (0.06)	0.406	+33.2	2/33 (0.06)
Maryland 1996 CBC law (excluding Baltimore)	0.440	+3.1	11/32 (0.34)	0.055	+10.8	4/24 (0.17)
Pennsylvania 1995 CBC law	0.167	+21.5	3/23 (0.13)	0.057	-10.0	5/19 (0.26)
Pennsylvania 1995 CBC law (excluding Philadelphia)	0.044	+23.9	2/14 (0.14)	0.027	+4.1	5/15 (0.33)
<b>Suicide</b>						
Maryland 1996 CBC law	0.060	-15.4	3/24 (0.125)	0.053	-21.8	1/32 (0.03)
Pennsylvania 1995 CBC law	0.024	+5.3	4/19 (0.21)	0.003	-11.8	1/11 (0.09)

Note. MSPE = mean square predicted error.

<sup>a</sup>The placebo results reported are the proportions of control states that had a more extreme placebo effect estimate than the effect actually estimated for the true treated state. We restricted the denominator to the subset of donor states with prelaw MSPEs less than 5 times the treated state's prelaw MSPE.

ATTACHMENT 1, Page 3 of 7

to Marshall Declaration

USDC Case No. 2:22-cv-01815-IM

AJPH October 2020, Vol 110, No. 10

**TABLE 2—Overall Synthetic Control Results for Purchaser Licensing Laws: Connecticut and Missouri, 1995 and 2007**

Model	Firearm			Nonfirearm		
	MSPE	Effect, %	Placebo No./Total No. (%) <sup>a</sup>	MSPE	Effect, %	Placebo No./Total No. (%) <sup>a</sup>
<b>Homicide</b>						
Connecticut 1995 purchaser licensing	0.371	-27.8	1/38 (0.03)	0.089	-0.7	20/33 (0.61)
Missouri 2007 purchaser licensing repeal	0.257	+47.3	0/6 (0.00)	0.037	+18.1	0/8 (0.00)
<b>Suicide</b>						
Connecticut 1995 purchaser licensing (through 2017)	0.109	-32.8	2/35 (0.06)	0.008	-3.3	15/25 (0.60)
Connecticut 1995 purchaser licensing (through 2006)		-23.2			-3.2	
Connecticut 1995 purchaser licensing (2007–2017)		-40.5			-3.4	
Missouri 2007 purchaser licensing repeal	0.208	+23.5	0/7 (0.00)	0.065	+6.9	1/4 (0.25)

Note. MSPE = mean square predicted error.

<sup>a</sup>The placebo results reported are the proportions of control states that had a more extreme placebo effect estimate than the effect actually estimated for the true treated state. We restricted the denominator to the subset of donor states with prelaw MSPEs less than 5 times the treated state's prelaw MSPE.

others. Despite this law, very few gun removals were carried out until 2007, after the mass shooting at Virginia Tech.<sup>25</sup> Research has shown that individuals subjected to these orders are more often suicidal than homicidal and that the removal law is associated with decreases in firearm suicides.<sup>26,27</sup>

To examine the possible effects of the removal law on our models of firearm and nonfirearm suicides in Connecticut, we split the effect estimate into 2 periods: 1995 to 2006 and 2007 to 2017. From 1995 to 2006, there was a 23.2% decrease in firearm suicides and a 3.2% decrease in nonfirearm suicides in Connecticut relative to the synthetic control. From 2007 to 2017, there was a 40.5% decrease in firearm suicides and a 3.4% decrease in nonfirearm suicides.

From 2007 to 2016, following the repeal of its purchaser licensing law, Missouri's firearm homicide rate rose 47.3% relative to its synthetic control (Table 2 and Figure 1; placebo = 0.00; 0/6). Over the same period, there was an 18.1% increase in nonfirearm homicides relative to the synthetic control (placebo = 0.00; 0/8). The estimated effect on firearm homicides was 2.6 times larger than that for nonfirearm homicides. There was an abrupt increase in firearm homicides immediately after the law's repeal and no such change in nonfirearm homicides (Figure 1 and Appendix Figure F, available as a supplement to the online version of this article at <http://www.ajph.org>). Missouri's repeal of handgun purchaser licensing was associated with a 23.5% increase in firearm suicides

(placebo = 0.00; 0/7) and a 6.9% increase in nonfirearm suicides (placebo = 0.25; 1/4) relative to the synthetic control (Table 2). Full truncated 10-year model results for Connecticut, Maryland, and Pennsylvania, as well as additional figures for all 4 states, are available in the appendix.

## DISCUSSION

Across the 4 state law changes examined in this study, purchaser licensing laws were consistently associated with lower rates of both firearm homicides and firearm suicides, but point-of-sale CBC laws were not. Relative to Connecticut's synthetic control, we estimated a 27.8% overall decrease in the state's firearm homicide rate and a 32.8% overall decrease in its firearm suicide rate. The decrease in firearm suicides was somewhat greater after the 2007 implementation of a risk-based firearm removal law. Although this could indicate complementary effects of Connecticut's purchaser licensing and gun removal laws, the number of removal orders is likely too small to achieve population-wide effects. A more plausible explanation is that suicide mortality continued to decrease because of a growing effect of licensing stemming from reduced access to firearms in the state. For Missouri, we estimated a 47.3% overall increase in firearm homicides and a 23.5% increase in firearm suicides. In tandem, the estimates for Connecticut and Missouri suggest that purchaser licensing laws are protective.

Our results are consistent with prior studies that also revealed protective effects of Connecticut's and Missouri's handgun purchaser laws.<sup>11–14</sup> Our study provides additional years of data and new statistical models that indicate larger protective effects for suicides in both states. In comparison with previous studies, our estimates of changes in firearm homicide rates associated with purchaser licensing were larger in the case of Missouri and smaller in the case of Connecticut. Other studies designed to estimate average associations across many law changes have also shown that licensing laws are associated with lower rates of firearm-related homicides<sup>5</sup> and suicides,<sup>12</sup> fewer fatal mass shootings,<sup>28</sup> and fewer instances of law enforcement officers shot in the line of duty.<sup>29</sup>

Although there were increases in Missouri in both firearm and nonfirearm mortality, the differences in firearm mortality were 2.6 times larger. The increase in nonfirearm homicides coincident with the repeal of Missouri's licensing law may indicate that other factors affected mortality rates in Missouri after the repeal of its licensing law and that the actual effect on firearm mortality was somewhat smaller than our estimate. In a recent study incorporating data through 2016, there was an estimated 27% increase in firearm homicides when changes in Missouri were compared with those in states from the region with similarly high baseline homicide rates.<sup>14</sup>

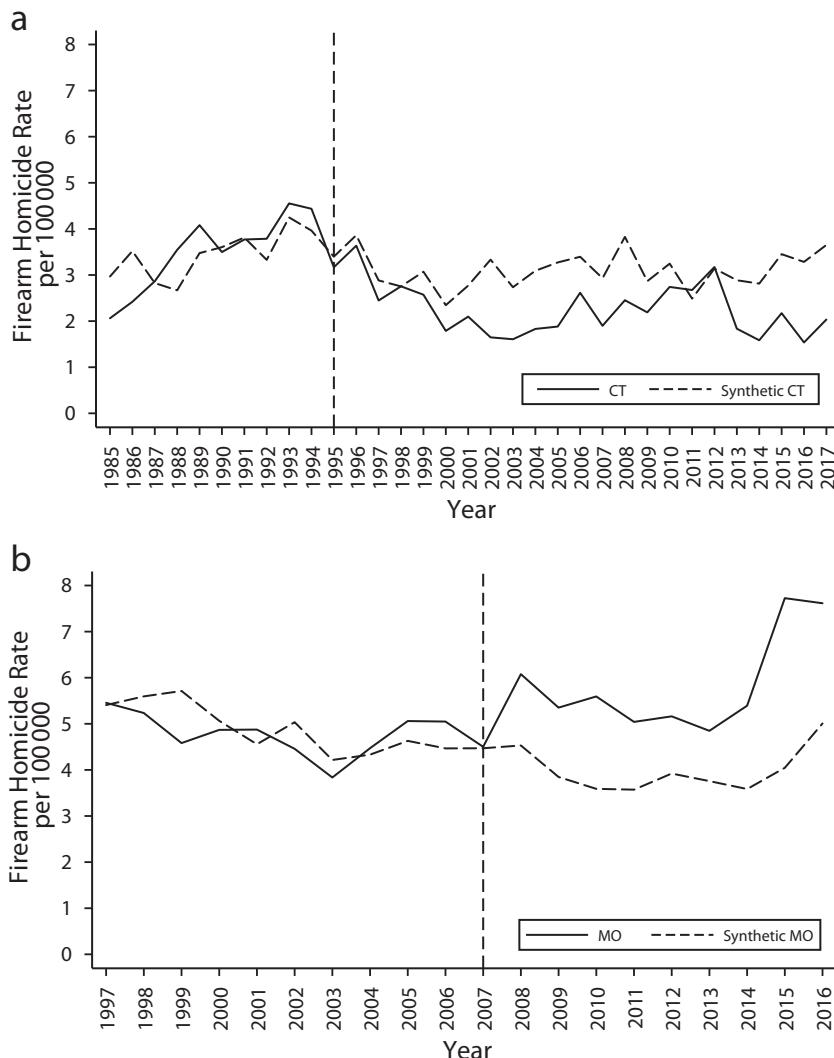
Maryland's CBC law was associated with increases in homicide rates; however, the increases were specific to Baltimore and were

ATTACHMENT 1, Page 4 of 7

to Marshall Declaration

USDC Case No. 2:22-cv-01815-IM

McCourt et al. Peer Reviewed Research 1549



**FIGURE 1—Effects of Purchaser Licensing Laws on Firearm Homicides in (a) Connecticut (Adopted 1995) and (b) Missouri (Repealed 2007)**

not evident in the rest of the state. This suggests that either conditions in Baltimore modified the law's effect or the estimate of the law's effect was biased by unmeasured confounders. It is unclear how to interpret the positive association between Pennsylvania's CBC law and homicide rates. If the law substantially limited the ability of potential homicide victims to access firearms and successfully defend themselves, one would expect an even greater harmful effect of licensing. Yet, licensing laws were linked to lower homicide rates.

Consistent with previous longitudinal studies,<sup>6,7</sup> CBC laws in Maryland and

Pennsylvania did not appear to reduce firearm suicides. Although Maryland experienced a decrease in firearm suicides after implementation of a CBC law, there was an even larger percentage decrease in nonfirearm suicides. This latter drop was more unusual in contrast to placebo states, suggesting that other factors may have been contributing to changing suicide rates in Maryland.

Comprehensive background check requirements may be necessary to prevent prohibited individuals from accessing firearms; without purchaser licensing requirements, however, they may be insufficient to achieve this objective and prevent lethal gun violence.

The effectiveness of CBC laws could be enhanced by more robust efforts to enforce the laws and promote compliance, broader prohibiting conditions, better record keeping, and expanded time to complete the checks.<sup>30</sup> A prior study documented infrequent enforcement of Maryland's and Pennsylvania's CBC laws,<sup>31</sup> which weakens the laws' capacity to deter illegal transfers of firearms. When Maryland added handgun purchaser licensing requirements to its CBC law in 2013, diversions of guns for criminal use shortly after retail sales dropped dramatically.<sup>32</sup> This suggests that point-of-sale CBC requirements in Maryland were an insufficient deterrent to illegal diversions without purchaser licensing.

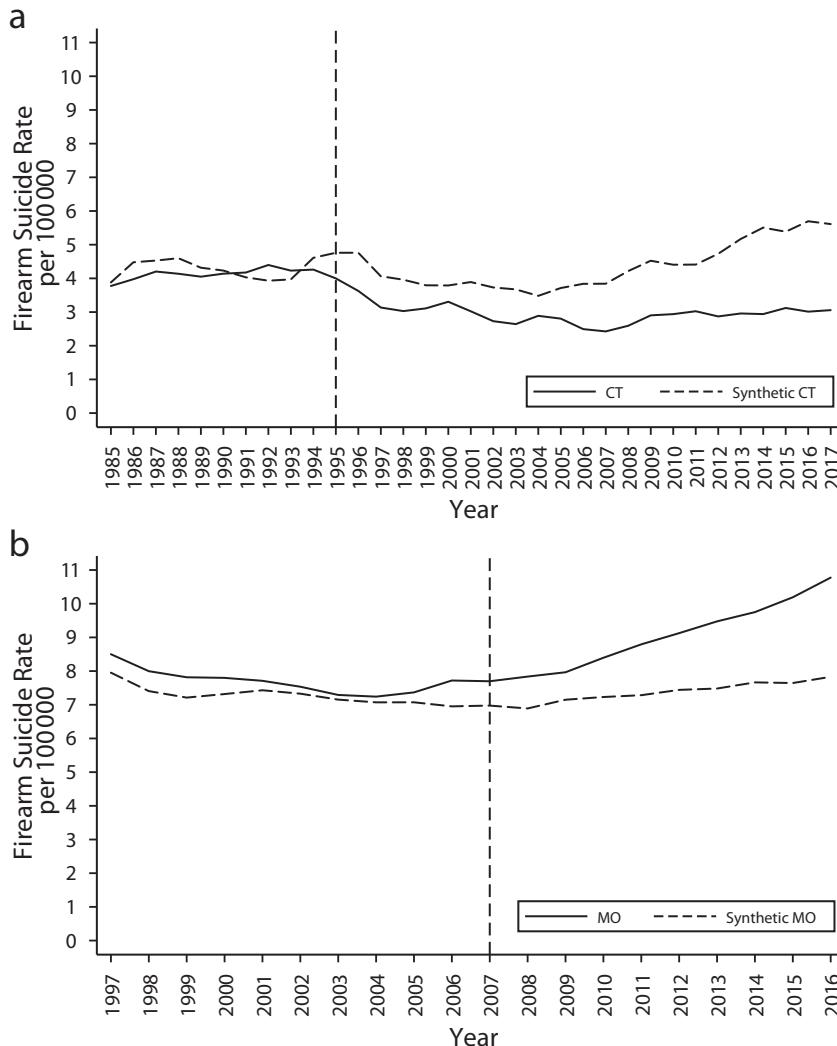
There are multiple reasons that firearm purchaser licensing might be more effective than point-of-sale CBC laws without licensing. Purchaser licensing requires vetting procedures that are more robust than is the case for point-of-sale CBC laws. This may deter individuals who might otherwise buy guns with the intention of criminal misuse or for transfer to a prohibited individual. States with purchaser licensing laws allow more time for vetting purchase applications and often check more complete sources of state data on prohibiting conditions than is the case under point-of-sale CBC laws. Firearm purchaser licensing also makes it easier for private sellers to verify that a prospective buyer is not prohibited from purchasing a firearm. Finally, licensing increases the real cost of purchasing firearms with additional time commitments and licensing fees. This likely reduces firearm ownership and the number of guns within a population.

The process required to obtain a purchaser license may also be protective with respect to suicide. It is much more difficult for individuals to make an impulsive decision to purchase a firearm if they need to secure a license first. Many suicide attempts occur within minutes or hours of initial suicidal ideation.<sup>33</sup> Longer waiting periods between applying to purchase firearms and receiving the firearms are associated with lower rates of firearm homicides and suicides.<sup>34</sup>

This study has potential limitations. First, we examined a limited number of law changes. For purchaser licensing, we assessed the only 2 law changes for which there were at least 5 years of postlaw data available. For CBC law changes prior law changes since

ATTACHMENT 6, Page 5 of 7

to Marshall Declaration  
USDC Case No. 2:22-cv-01815-IM  
AJPH October 2020, Vol 110, No. 10



**FIGURE 2—Effects of Purchaser Licensing Laws on Firearm Suicides in (a) Connecticut (Adopted 1995) and (b) Missouri (Repealed 2007)**

1990 had already been evaluated,<sup>9</sup> and recent changes provided few postlaw data points. Second, although the synthetic control method is a robust strategy for estimating policy effects, the control pool for our analyses was somewhat limited in the case of Missouri.

Third, we sought to expand on previous work by extending the time period for each model to include the latest possible year of data. Our results are, therefore, more informative, but longer postlaw periods may create some uncertainty with respect to the capability of the models to accurately estimate the counterfactual. Finally, visual analysis of some of our synthetic control plots revealed that

although the prelaw MSPE was minimized, there was a separation between the synthetic control and the treated state just before a law change. Such separation prior to a change could be random variation or could be indicative of unmeasured factors influencing trends between prelaw and postlaw change periods that might bias effect estimates.

Despite these limitations, our analyses have many strengths. We used a rigorous statistical method that minimizes errors in model prediction. We contrasted the patterns of estimated law effects across firearm and nonfirearm homicides and suicides to assess whether estimated effects were specific to

deaths involving firearms. The CBC laws and one of the purchaser licensing laws were all adopted in 1995 or 1996, allowing for comparisons within the same historical period. We offered a fourth law change, Missouri's repeal of purchaser licensing during a time of relatively stability in homicide trends in Missouri and nationwide, to contrast with Connecticut's implementation of purchaser licensing in a different region and time period.

Although data on public support for firearm policies reveal somewhat broader support for CBC laws than is the case for purchaser licensing, a 2019 national survey reported 77% support for handgun purchaser licensing.<sup>35</sup> CBC laws are critical for keeping firearms from high-risk individuals, but they may be insufficient to significantly reduce firearm mortality without purchaser licensing. **AJPH**

## CONTRIBUTORS

A. D. McCourt led the writing and analyses. A. D. McCourt, C. K. Crifasi, E. A. Stuart, J. S. Vernick, and D. W. Webster designed the study and statistical analyses. R. M. C. Kagawa and G. J. Wintemute provided critical review and interpretation of the data, analyses, and findings. All of the authors contributed to data interpretation and critical revisions of the article.

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## CONFLICTS OF INTEREST

The authors have no conflicts of interest to disclose.

## HUMAN PARTICIPANT PROTECTION

No protocol approval was needed for this study because secondary data sources were used to analyze aggregated mortality rates.

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ATTACHMENT 9, Page 6 of 7

to Marshall Declaration

USDC Case No. 2:22-cv-01815-IM

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ATTACHMENT 9, Page 7 of 7

to Marshall Declaration

USDC Case No. 2:22-cv-01815-IM

AJPH October 2020, Vol 110, No. 10